HEALTH RISK ASSESSMENT OF SELECTED HEAVY METALS IN SOME IMPORTED CHOCOLATES SOLD IN SOUTHWESTERN, NIGERIA

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ABSTRACT

Consumption of chocolate is common among Nigerian children who live in the cities. In spite of the palatability and nutritional significance of chocolate, it hardly exists without traces of heavy metal contamination. The study was carried out to evaluate the level of selected heavy metals in chocolate and their potential health impacts on children who consume the product on regular basis. Thirty (30) brands of chocolates v including 26 milk and 4 dark chocolates were purchased and analyzed. The total hazard quotient ranged between 0.06 – 0.25 for Ni while it ranged between 0.03-0.13, 0.03-0.09, 0.06-0.47, 0.0015-0.0042 and 0.029-0.10 for Pb, Zn, Cu, Cr and Fe respectively. The low values of calculated target hazard quotient suggests the safety of the investigated chocolates with respect to heavy metal contamination.

Keywords: *Heavy metal Contamination, Chocolates, Health implication, South west*

INTRODUCTION

Chocolate is a typically sweet, brown food preparation of *Theobroma cacao* seeds. The seeds are usually roasted and ground in form of a liquid paste or in block. Much of the chocolate consumed today is in form of sweet chocolate, a combination of cocoa seeds, cocoa butter or other fat and sugar. Milk chocolate is a sweet chocolate that additionally contains milk powder or condensed milk, while the white chocolate contains cocoa butter, sugar and milk but no cocoa solids (Miller et al. 2006).

In spite of the various health benefits and pleasure associated with the consumption of chocolates of cocoa origin, the issue of heavy metal contamination in the product has become a global concern. Before chocolate is ready for consumption, the product passes through diverse industrial processes which involve machinery and packaging (provides means of protection, marketing and safe handling). Some of the colored printing done on the wrappers for the purpose of enticement, beautification have metals origin. Heavy metals such as Pb, Cr, Ti, Zn and Cu can migrate from the printed surface to the product through blocking, rubbing, peeling and diffusion (Bradley et al. 2005). The consumption of chocolate is common among Nigerian children especially those in the cities. Contamination of imported food products with heavy metals may cause a serious risk for human health because of the physiological effects of heavy metals. Consumption of even small quantity of metals can lead to considerable bio-toxic effects. Though individual metal exhibit specific signs of toxicity, many illness like gastrointestinal disorders, diarrhea, stomatitis, depression, pneumonia and many other have been reported as general signs associated with Cd, Pb, As, Hg, Zn, Cu and Al consumption. In addition, young children are considered to be at greatest risk due to their ability to effectively absorb metals and thereby suffer physiological development retardation (Kocak et al. 2005).

Data on metals concentration in foods at the point of consumption is necessary in order to estimate health risk associated with heavy metal contamination in chocolate. In Nigeria, data on heavy metal contamination in chocolate and potential health risk associated with long term consumption among children is limited. Hence, the study evaluates the level of selected heavy metals and potential health risk indices associated with consumption of common brands of chocolate in Ibadan, southwestern Nigeria.

MATERIALS AND METHODS

Thirty (30) chocolate samples containing 26 milk chocolate and 4 dark chocolates were purchased from selected supermarkets within Ibadan metropolis. Ibadan is the largest indigenous city in West Africa which is located in the south western part of Oyo state, Nigeria. Each of the samples was homogenized by blending in a stainless steel blender. After homogenization, 2g of each sample was weighed into a 50ml beaker followed by the addition of 20ml Nitric /Perchloric acids) (3:1 v/v) and digested for 2 hours at the temperature of 150^{o}C. After digestion, the digests were analyzed for Fe, Cu, Zn, Pb, Cr and Ni using Buck 210 VGP Atomic Absorption Spectrophotometer.

Target Hazard Quotient

The health risk associated with heavy metals exposure through the consumption of chocolate was evaluated using the target hazard quotient (THQ) (Liu et al., 2006).

$$THQ = \frac{EF \times FD \times DIM}{RfD \times W \times T} \qquad (1)$$

Where EF is the exposure frequency (365d/year), FD is the exposure duration (6 years), DIM is the daily metal ingestion (mg/person/day), RfD is the oral reference dose (mg/kg/day), W is the average body weight (20kg), T is the average exposure time for non carcinogen (365 days/year x number of exposure years). THQ is a highly conservative and relative index (Wang et al, 2005). If THQ is less than 1, there is no obvious risk from the substance over a lifetime exposure, while if THQ is higher than 1, the toxicant may produce an adverse effect. The higher the THQ value, the higher the probability of experiencing long term carcinogenic effects. (Song et al. 2009)

RESULTS

Target hazard quotient (THQ)

THQ though, does not provide quantitative estimate on the probability of an exposed population experiencing a reverse health effect, it offers indication of the risk level due to contaminant exposure. The THQ index can be defined as the ratio of determined dose of a pollutant to the reference dose (RfD) (μg/kg bw/d).The following were the values used for oral reference dose: Fe (0.700), Zn (0.300), Cu (0.040), Ni (0.02), Pb (0.0035) and Cr (1.5) (USEPA, 2010)

The calculated target hazard quotient of Ni for a child that consumes 20g chocolate every day of the week for six years (THQ_{365}) ranged between 0.06 and 0.26

The calculated Target hazard quotient of Pb ranged from 0.03 to 0.13 for a child that consumes 20g chocolate everyday of the week while the calculated total hazard quotient of Cr, Cu, Zn and Fe had range of 0.0015 – 0.0042, 0.06-0.47, 0.03 – 0.08 and 0.029-0.10 respectively for a child who consumes 20g of the chocolates on a daily basis for a period of six years.

Table 2: Calculated Total hazard Quotients of heavy metals in chocolates.

	Target Hazard Quotient 365 $_{days}$					
	Ni	Pb	Zn	Cu	Cr	Fe
1(milk)	0.06	0.07	0.03	0.08	0.0015	0.044
2(milk)	0.17	0.00	0.04	0.13	0.0021	0.071
3(milk)	0.11	0.09	0.04	0.12	0.0027	0.056
4(milk)	0.13	0.06	0.05	0.10	0.0023	0.054
5(milk)	0.26	0.03	0.04	0.06	0.0042	0.031
6(milk)	0.18	0.13	0.06	0.16	0.0032	0.055
7(milk)	0.25	0.05	0.05	0.07	0.0038	0.100
8(milk)	0.13	0.07	0.05	0.08	0.0020	0.034
9(milk)	0.14	0.09	0.04	0.13	0.0017	0.042
10(milk)	0.16	0.09	0.03	0.09	0.0019	0.053
11(milk)	0.09	0.00	0.03	0.07	0.0021	0.068
12(milk)	0.13	0.10	0.04	0.11	0.0039	0.097
13(milk)	0.21	0.03	0.05	0.09	0.0028	0.072
14(milk)	0.16	0.08	0.03	0.11	0.0031	0.045
15(milk)	0.12	0.05	0.06	0.13	0.0021	0.049
16(milk)	0.13	0.12	0.06	0.08	0.0018	0.054
17(milk)	0.14	0.06	0.05	0.11	0.0019	0.057
18(milk)	0.08	0.03	0.04	0.08	0.0025	0.037
19(milk)	0.07	0.08	0.05	0.10	0.0028	0.051
20(milk)	0.16	0.09	0.05	0.16	0.0025	0.065
21(milk)	0.15	0.12	0.04	0.17	0.0034	0.029
22(milk)	0.12	0.10	0.06	0.13	0.0033	0.038
23(milk)	0.11	0.05	0.04	0.10	0.0021	0.095
24(milk)	0.22	0.06	0.04	0.10	0.0020	0.059
25(milk)	0.18	0.08	0.05	0.11	0.0030	0.043
26(milk)	0.10	0.00	0.05	0.12	0.0034	0.036
27(dark)	0.12	0.04	0.08	0.41	0.0041	0.033
28(dark)	0.26	0.10	0.07	0.36	0.0035	0.097
29(dark)	0.19	0.13	0.09	0.47	0.0020	0.044
30(dark)	0.26	0.04	0.08	0.34	0.0029	0.040
Mean	0.15	0.07	0.05	0.15	0.0027	0.055
Min	0.06	0.03	0.03	0.06	0.0015	0.029
Max	0.26	0.13	0.09	0.47	0.0042	0.100

Key: milk= milk chocolate; dark= dark chocolate

DISCUSSION

Nickel

The calculated target hazard quotients for nickel (Table 1) indicates that, a child who weighs 20kg and consumes 20g of chocolate everyday of the week for a period of six years is not likely to have any health concern as a result of low THQ calculated for nickel in all the 30 samples which was found to be less than 1. A hazard quotient is the ratio of the potential exposure to a substance and the level at which no adverse effects are expected. If the target hazard quotient is calculated to be less than 1, then no adverse health effects are expected as a result of the exposure. However, if the calculated target hazard quotient (THQ) is greater than 1 then, there is a reason for health concern (Sharma and Agrawal, 2005). It must be noted that THQ is not a measure of risk (Chien et al. 2002 and Wang et al. 2005) but indicates a level of concern. In

a related account, Iwagbue et al. (2013) also reported THQ for 15 ready –to –eat food in southern Nigeria where 11 samples had THQ values less than 1 while the rest 4 samples had THQ values higher than 1. It is however advisable for children who are regular consumers of chocolate to be moderate in eating the commodity.

Lead

The level of target hazard quotient for Pb obtained for the 30 brands of chocolate investigated in the study (0.03-0.13) shows there may not be any health concern for a child (20kg) who consumes 20g of the chocolate everyday of the week. However, children who are lovers of chocolate should not be encouraged to go into excessive consumption of the product considering the physiological implication of abnormal concentration of Pb in human system, with emphasis on young children. According to the report of Yanus et al (2014), young children risk exceeding recommended limits for Pb when consuming chocolate in excess. Yanus et al. (2014) assessing the human risk of trace metals in chocolate stated that although the Pb concentration found in a variety of global brands of chocolates, were below the USA standard of 1,000ngg^{-1} limit, the Pb concentration should still be considered a health concern.

Copper

Target hazard quotient (Table 2) calculated for copper in the study ranged from 0.06 to 0.47. This suggests that consumption of 20g chocolate on a daily basis may not pose health threat to chocolate consumers since the obtained values are much lower than 1.

Chromium

The low values of target hazard quotient obtained for Cr in the investigated chocolates (Table 2) is an indication that a child who has a daily consumption of 20g of any of the imported chocolate examined in the present study is not likely to have any health concern as a result of Cr toxicity. This is due to the fact that the THQ values obtained in the study ranged between 0.15 and 0.42%

Zinc

In table 2, the estimated target hazard quotient (0.03 -0.08) ranged between 3 and 8% of the safe THQ value. This indicates that the daily consumption of 20g chocolate by a child of average weight of 20kg is not likely to pose health threat on children who eat chocolate on daily basis.

Iron (Fe)

Iron is mainly a deficiency problem and not a toxicological problem and it is generally acknowledged to be the most common single nutritional deficiency in both developing and developed countries (Nordic Council of ministers, 1995). Under normal conditions, about 5-15% of Fe in food is absorbed (Elinder, 1986). Iron salts like ferrous sulphate and ferrous succinate are commonly used for the treatment and prevention of iron deficiency in humans (Beliles, 1994).

CONCLUSION

The study revealed that the concentration of the metals considered in the study were within the acceptable limits except for copper in dark chocolates. The study showed that, daily consumption of 20g of any of the

investigated chocolates cannot supply the required daily amount of Cr, Zn and Fe needed by the body. Hence, other food sources will be required to supply the nutritional deficit. Quantity of cocoa solids in chocolate determined the level of copper and zinc in the commodity.

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